Loren Franklin Steiner, 1904-1977
A Biographical Sketch

ERNEST J. HARRIS[1]

Loren Franklin Steiner died May 13, 1977 at the age of 73 years while visiting Donald W. Hamilton and other friends in Vincennes, Indiana. His passing was a great loss to his family, a large circle of friends, and the scientific community in Hawaii, Florida, and the rest of the continental United States and the world. Dr. Loren F. Steiner was a world-renowned scientist who revolutionized technology for the detection, suppression, and eradication of fruit flies. He helped to establish Hawaii as the world leader in research on innovative methods of fruit fly control. Moreover, he strongly influenced developments in economic entomology in the control of fruit insect pests through his prolific writings, actual participation and research leadership.

Dr. Steiner was born in Bluffton, Ohio, and received his Bachelor of Science and Master of Science degrees from Ohio State University in 1926 and 1927, respectively. He won a 4-year competitive examination scholarship while at Ohio State University. This training laid the foundation for subsequent work for which Ohio State University awarded him the Honorary Doctor of Science degree in 1967.

Loren began his professional career in 1927 as an Assistant Entomologist at Purdue University conducting research on the control of the codling moth and the oriental fruit moth. His research approach was to study the behavior of the insect under investigation in its natural environment and use this knowledge to develop integrated control methods. Dr. Steiner developed new codling moth baits, proper timing of sprays, and alpha naphthylamine-treated bands to kill codling moths. In 1930 Loren joined the U.S. Department of Agriculture at Cornelia, Georgia. In his first 2 years with the Department, he was in charge of an oriental fruit moth bait trap experiment in 500 acres of peach and apple orchards at Cornelia. He demonstrated that inter-orchard moth movement was extensive, and that trapping with ethyl cinnamate or terpenyl acetate-brown sugar baits could be a highly effective method of control if used in isolated or large orchard areas.

After 4 years in Georgia Loren transferred to Vincennes, Indiana. He was placed in charge of the Fruit Insect Investigations laboratory in Vincennes and a substation at Orleans, Indiana. He worked closely with the USDA chemists and a plant pathologist to develop lead arsenate substitute spray treatments that would best control both pest and disease problems with a minimum of residue hazards. He modified and streamlined a laboratory-field method of evaluating spray programs week by week throughout the growing season, using stratified samples artificially infested. He also improved rearing and infestation techniques so that screening of insecticides could be continued throughout the winter. This

1. Hawaii Fruit Flies Laboratory, USDA, Agricultural Research Science and Education Administration, P. O. Box 2280, Honolulu, HI. 96804.

work led to the development of the tank-mix nicotine-bentonite-oil formula for codling moth control that saved many apple growers in the Middle West from bankruptcy and was worth millions of dollars in overall savings to the industry.

Dr. Steiner actively participated in and supervised large-area tests of orchard sanitation, bait traps, and light traps. By releasing thousands of marked codling moths, he and his staff demonstrated the capability of this pest to move between plots and obscure results of some treatments. He was especially talented in his ability to uncover characteristics of pest insects pertinent to evaluation and improvement of control. After conducting preliminary laboratory tests with DDT, Dr. Steiner and his staff demonstrated in the first field tests in the United States the remarkable effectiveness of this new insecticide against the codling moth. Dr. Steiner was the first to observe the adverse effect of DDT on mite predators and the resultant outbreak of two species of mites. He personally made four surveys of 26 or more commerical apple orchards in Indiana and Tennessee each season for several years to determine the relationship between mite outbreaks and climate, or grower practices, and insecticide usage.

Dr. Steiner and his staff worked out effective programs combining minimum amounts of lead arsenate, DDT and new organic phosphates such as parathion that gave the best control of all pests on apples and permitted fungicide usage. They found that summer applications of organic phosphate and DDT would leave residues on or under loose bark that were highly effective in destroying larvae that overwintered in contact with these residues. Such sprays were found to be sufficiently effective to eliminate the need for dormant oil sprays.

In 1949, Dr. Steiner was transferred to Hawaii to a position as Chemical Control Project Leader in the Fruit Fly Investigations Laboratory. He supervised screening of thousands of candidate insecticides and field-tested most that reached a marketable stage of development. While personally studying oriental fruit fly behavior in the presence of several potential attractants under field conditions, he discovered that male oriental fruit flies would feed avidly on pure methyl eugenol. In a similar manner, he was the first to discover that both sexes of fruit flies could be attracted strongly to foliar deposits of hydrolyzed proteins and that by adding small amounts of fast-acting poisons to either type of attractant, heavy mortality and long-distance attraction could be obtained with amounts of insecticides much smaller than required in conventional sprays.

The subsequent research with methyl eugenol, which he planned and actively participated in, led to phenomenal success in population suppression of the oriental fruit fly in non-isolated areas up to 6 mile', and in the isolated Bonin Islands of 28 mile'. Then, in 1962-63, the oriental fruit fly was eradicated from Rota (33 mile') in the first successful use of the new male-annihilation method.

First, during the Bonin Island tests and, later, on Rota, he found that when populations of oriental fruit fly males were reduced to less than 1% of normal levels, sexually mature virgin females were strongly attracted to and killed by the poisoned lure in traps, bait stations, or on foliage. Later

he instituted tests that showed that medfly females would respond to trimedlure in the absence of males, and in tests with trimedlure which he supervised in the Portuguese Azores, enough male suppression was obtained in some areas to stimulate a strong female response.

In 1950, he and an associate developed a new outdoor cage-type olfactometer. In a long screening program involving 30-40 thousand candidate lures obtained from industry and USDA Pesticides Chemicals Research Branch (PCRB), he and two other members of his staff found angelica seed oil an effective male Mediterranean fruit fly (medfly) lure and, later, studies with several esters of cyclohexene (and cyclohexane) carboxylic acid culminated in the development of siglure, medlure, and trimedlure. Angelica seed oil and, later, siglure and trimedlure were used to detect and survey medfly infestations in the 1956 and 1962 medfly eradication programs in Florida. Trimedlure is now the standard male Mediterranean fruit fly lure and is widely used in medfly areas around the world.

Dr. Steiner was appointed Investigations Leader of the Hawaiian Fruit Flies Investigations Laboratory in 1955. His administrative duties increased, but his inquisitiveness as a scientist and keen interest in research kept him closely involved in the implementation of all research in the Hawaii laboratory. He had so much energy and enthusiasm for research that he did not become tied down by his administrative duties. Dr. Steiner's modification of the olfactometer late in 1956, to permit tests of residual effectiveness on wicks such as used in traps, led to the discovery of the superiority of siglure to earlier synthetic medfly attractants. Dr. Steiner's strong emphasis on field tests as the ultimate determinant of eficacy of lures became the hallmark of the Hawaiian Fruit Flies Laboratory in the development of fruit fly detection, suppression, and eradication technology.

Dr. Steiner, with assistance from his staff and PCRB, discovered the attractiveness of anisylacetone to the melon fly. Later, a study of several of its analogues culminated in the development of cue-lure, now the most effective attractant for the melon fly and Queensland fruit fly. He found cue-lure also attractive to *Dacus passiflorae*, Froggatt, a citrus pest in Fiji, on his return from a consultant assignment in Australia.

His discovery of the attractiveness of protein hydrolysate to fruit flies led to the development, through a long series of tests by him and his staff, of highly effective bait sprays of hydrolysates or autolysates of grain, yeast, milk, meat and other proteins, combined with organic phosphates or carbamates. For these tests he devised a tray method of evaluation that permitted studies on the effects of rainfall and other factors on different formulations and application rates. By canvassing all possible sources of acid and enzymatic hydrolysates, and evaluating samples by tray tests, he found Staley's Sauce Base #2 to be as effective as, but 95% less costly than, the first enzymatic types used. He later found Standard Brands Type M which, for many years, was the best low-cost enzymatic protein hydrolysate available for use in adult diets.

The protein hydrolysate-malathion formula applied by aircraft made possible eradication of the Mediterranean fruit fly from 800,000 infested

acres in 28 counties in Florida in 1956-57 (and of new infestations discovered in 1962 and 1963). The savings to the southeastern United States was estimated at $20 million annually as compared with $300 million to live with the fly. While serving as technical advisor to the Florida medfly eradication program, Dr. Steiner developed a dry plastic trap and suitable methods of using angelica seed oil that saved $89,000 in trap costs during 1956 alone. Before leaving Florida, he drafted a survey and detection manual for trappers. Later, after more tests in Hawaii, methods of using the trap were improved, and the best methods of using the new lures alone or in combination were perfected and recommended to California and Florida officials. The Steiner trap is now in widespread use for survey purposes in the U.S. and foreign areas, and the principal manufacturer has sold more than 1/3 million traps. The trapper's manual has been updated several times as additional research revealed better survey and detection methods.

In 1965, Dr. Steiner and his staff initiated tests with undiluted formulations of technical malathion or naled and a liquid protein hydrolysate. These formulations prepared without water permitted higher flying (required over rough terrain in Hawaii), in lines further apart, with far less volume (15-20 oz formulations/acre) than conventional sprays and under wind and low humidity conditions that would prevent use of either ultra-low volume insecticide or conventional bait sprays. This malathion-protein hydrolysate formulation was used to eradicate an outbreak of the medfly at Brownville, Texas, in 1966 and is now used throughout the world for medfly control. Israeli scientists, after visiting the Hawaiian laboratory, adopted the bait-spray program for medfly control and obtained a substantial increase in the production of high-quality citrus at less cost for medfly control. Australian officials are using it for control of the medfly in Western Australia and the Queensland fruit fly in eastern Australia, and also to eradicate introductions of either species into uninfested areas.

Dr. Steiner planned and supervised the first laboratory tests of the sterile-fly release method on tephritids early in 1955, using a 1-curie Cobalt-60 source and demonstrated in sterile:normal ratio and paired mating tests that multiple mating need not be a deterrent to application of the method for fruit fly control. Dr. Steiner and his staff conducted the first field tests of sterile insects in Hawaii, using 18 million Mediterranean fruit flies over a 1-year period with good suppression in a 12-mile' non-isolated area. Subsequently, after assisting his rearing staff to reduce costs from more than $350/million flies in 1957, to $45 by 1961, and $20 by 1968, and after confirming the minimum effective irradiation dosages found with the 1-curie source, he and his staff shipped 1.4 billion sterile pupae (oriental fruit fly and melon fly) 3800 miles to the Mariana Islands from 1960 to 1967 and released one or both species on Guam, Rota, Tinian, Saipan and Aguiguan.

After failing to eradicate a heavy infestation of the oriental fruit fly on Rota, the sterile-insect release method was applied to the melon fly and the first eradication of any insect, other than the screw-worm, was achieved with this species on Rota. In September 1963, Dr. Steiner, while plotting fruit fly distribution on Guam from trap catches, found that most

oriental fruit flies were breeding in localized areas at one end of the island after populations were depressed by typhoon Karen's effects on host plants in 1962. He recognized the opportunity to eradicate this pest by limited releases of sterile flies and instituted releases (of a white-marked strain developed at the laboratory) for several months with the support of two staff members. Later, with the help of Guam officials, the 35-year-old infestation of the oriental fruit fly was eradicated with the release of only 40 million sterile flies at a cost of only 8¢/acre. Still later, by applying the male-annihilation method, in cooperation with Trust Territory officials, the last oriental fruit fly infestation in the Marianas was eradicated on Saipan, Tinian and Aguiguan in 1965, and no reinfestation has occurred on these islands since then.

During the Western Pacific eradication programs, Dr. Steiner spent about 400 days (divided among 22 round trips) on the various islands in surveying for the programs, in active participation, training a succession of staff members temporarily assigned to the project, substituting for personnel, investigating causes of excessive fly losses, and in maintaining good working relationships with the U.S. Navy, Trust Territory, and Guam officials. Because of the severe logistical problems, help was obtained from the U.S. Navy, MATS, and U.S. Post Office in transporting personnel, supplies and sterile pupae. The Navy cooperated fully in the aerial distribution of flies on Rota and of the male lure treatments on Rota and in the Bonin Islands. During the program, Dr. Steiner developed an efficient method of detecting dye-marked flies and of estimating native fly populations and release rates for overflooding based on catches by male-lure survey traps. At least five reintroductions of the melon fly to Rota (usually after strong winds from Guam) were eradicated by Trust Territory officials using sterile flies and suggestions supplied by Dr. Steiner and his staff.

In 1963, he suggested and assisted in the evaluation of monoglycerides of lard and other thickening agents as extenders in lure-toxicant formulas for application to foliage to improve male-annihilation formulations, of new methods of conducting mating tests, and of improving fly-distribution containers. From 1957 to 1968 he supervised all commodity treatment research (most publications were by the staff) and was active in promoting the use of gamma-irradiation, serving on an ad hoc committee that guided the State in the procurement of a large commercial-type irradiation facility for treating packaged Hawaiian fruits and vegetables that could not be effectively fumigated.

The first research on chemosterilants for fruit flies was initiated in 1955 under Dr. Steiner's supervision. Several were found highly effective incorporated in water, protein hydrolysate, or in the synthetic male lures.

For more than 1 year in 1964-1965, Dr. Steiner also supervised a special project financed by contingency funds to develop mass-production methods for the Southern green stink bug.

Dr. Steiner was the recipient of many awards for his accomplishments. These included three Superior Service Unit Awards, an Individual Superior Award, an award for development of the fruit fly trap that bears his name and an Outstanding Performance Citation, all from the U.S. Department of Agriculture. In addition, he received an Honor Award from the

Florida Entomological Society in 1960 for his efforts toward eradication of the Mediterranean fruit fly from Florida in 1956-57. In 1966 he was the first recipient of the annual J. Everett Bussart Memorial Award in recognition of his "outstanding work in Economic Entomology." In 1967 he was awarded an Honorary Doctor of Science Degree by Ohio State University for his outstanding work and for being an outstanding alumnus of that institution.

After his transfer to Florida in 1968, Dr. Steiner and his staff in cooperative tests with USDA Plant Pest Division (PPD), Florida Department of Plant Industries (DPI), and the University of Florida, found undiluted bait sprays superior to ULV malathion for Caribbean fruit fly control. He suggested and supervised tests of a new torula yeast hydrolysate in traps that proved 5-7 times better than the previous standard. This has been adopted by PPD and DPI for use in their survey program. Dr. Steiner also supervised or conducted tests to develop minimum irradiation dosages and to study effects of chilling on the Caribbean fruit fly. He designed certain equipment and planned most of the procedures for conducting a pilot test of the sterile-fly release method to eradicate the Caribbean fruit fly on Key West in cooperation with state and federal agencies, the U.S. Navy and the local authorities. He also suggested and supervised research on a low-cost new diet for larvae based on corncob grit and the standard nutrients.

In tests that required more than 80,000 free-flying Caribbean fruit flies released in airplanes and vans, he and three assistants evaluated many aerosol and micronized-dust formulas as possible DDT substitutes for use by Plant Quaratine in disinsection operations. Tests with fruit flies and many other insects were conducted simultaneously by several cooperating agencies. These tests not only served to eliminate many formulas that would not require further evaluations against other fruit fly species, but also produced several that were highly promising.

Throughout entomological circles, Dr. Steiner was well known for his research on biology and control of fruit flies. During his career, he held more than 20 temporary assignments in 17 foreign countries as a research consultant on fruit fly biology, control and eradication. In addition, he was a technical advisor during several successful programs to eradicate the Mediterranean and oriental fruit flies from the mainland.

In addition to his research responsibilities, Dr. Steiner was throughout his career an active member of Sigma XI, the Rotary Club, and the Methodist Church.

Dr. Steiner is survived by his wife, Dorothy, of Clearwater, Florida, a son, Galen, a daughter-in-law, and a grandson, of Las Vegas, Nevada. A memorial scholarship has been established in his name at Ohio State University.

This is the legacy of a scientist and a friend from whom I learned fruit fly population ecology and management with integrated control methods during work and quiet moments in the field. He is no longer with us, but the technology he developed lives on with greater visibility.

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